Australasian Plant Conservation

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Historic seed collections germinated for the Australian PlantBank opening

Are seed banks misunderstood? A perspective from the Millennium Seed Bank

Seed production project produces translocation spin off for a highly threatened species

A comparison of germination stimulants applied to five difficult to germinate native species from Queensland

And much much more …

SPECIAL THEME: SEEDS

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. **The deadline for the March–May 2014 issue is Friday 14 February 2014.** The theme for the issue will be *Global Strategy for Plant Conservation*. General articles are also very welcome. Please contact Huw Morgan if you are intending to submit an article: huw.d.morgan@gmail.com.

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Front cover: Tasmanian Fruit collection for the Millennium Seed Bank Australian partnership. Photo: Royal Botanic Gardens, Kew
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Contents

From the editor *by Selga Harrington* 2

President's Report *by David Coates* 2

Are seed banks misunderstood? A perspective from the Millennium Seed Bank *by Paul Smith* 5

Historic seed collections germinated for the Australian PlantBank opening *by Monica Fahey, Amelia Martyn and Cathy Offord* 7

Meeting the seed needs for future restoration *by Paul Gibson-Roy and John Delpratt* 9

Seed production project produces translocation spin off for a highly threatened species *by David Taylor, Joe McAuliffe, Tom North, Paul Gibson-Roy, Bindi Vanzella, Nicki Taws, Greg Baines, Emma Cook, Brendan Lepschi and Linda Broadhurst* 11

Germination of the endangered species Port Lincoln Speedwell in response to season and fire cues *by Jenny Guerin, Michael Thorpe, Dan Duval and Phillip Ainsley* 13

A comparison of germination stimulants applied to five difficult to germinate native species from Queensland *by Tima Racule and Philip M. Cameron* 15

Brief notes on *Baeckea kandos*, a highly restricted endemic from Wollemi National Park *by Steve Clarke* 17

Regular features

ANPC Member profile 19

Recent workshop reports 20

Upcoming conferences and workshops 23

Book review 25

Information resources and useful websites 26

Research round up 27

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ANPC thanks the Millennium Seed Bank, Kew United Kingdom for its sponsorship of this issue of *Australasian Plant Conservation.*

From the editor

Selga Harrington

Parsons Brinckerhoff

Welcome to the summer edition of Australasian Plant Conservation! The theme for this edition is seeds! This issue includes articles on a range of issues from germination cues and dormancy, longevity and storage, seed banking, and the use of seed in revegetation and conservation.

This issue is sponsored by the Millennium Seed Bank in Kew, UK and commences with an article on the Millenium Seed Bank, its aims and funding. The following article discusses some surprising results from the germination of historic seed collections (mostly between 1890 and 1920) for the opening of the Australian PlantBank at Mt Annan Botanic Gardens, Sydney. The issue also contains articles on seed harvest and production for restoration works including seed production and translocation of the highly endangered Ginninderra Peppercress. The testing of germination cues are investigated in two articles examining cues for five difficult to germinate Queensland species and the endangered South Australian Lincoln Speedwell. The final article provides some new information on the distribution and ecology of *Baeckea kandos*, a highly restricted endemic from Wollemi National Park.

This issue also includes the President's report from the Annual General Meeting and concludes with the regular features: a profile on an ANPC member, Recent workshop reports, Upcoming conferences, Information resources and useful websites and finally the Research roundup.

This is my last issue as Editor of Australasian Plant Conservation. Huw Morgan will be taking over from the next issue. I would like to thank ANPC staff and Committee members, past and present, who have helped with each issue. My thanks also to all those who have contributed articles over the last three years; keep them flowing in!

Happy reading!

President's Report

David Coates

President, Australian Network for Plant Conservation Inc

The ANPC has continued this year to play a key role in facilitating and communicating plant conservation initiatives throughout Australia. I have again been impressed by the dedication and breadth of knowledge of ANPC members and the key position it has in Australia in promoting linkages between the many interest groups that are dedicated to the conservation of Australia's plant species, communities and ecosystems.

We are now completing our 22nd year, a remarkable effort for a non-government organisation which has a focus on biodiversity conservation. There continues to be a high level of community interest and support for plant conservation. This is reflected not only in the sustained level of membership in the ANPC but also in the ongoing participation of land managers, government departments, industry, the volunteer conservation movement and the broader community in ANPC workshops and Conferences.

There will continue to be significant challenges for us and some of these were raised at our Conference in 2012. They include addressing our core business of facilitating the conservation of a unique flora, the recovery of threatened species, ecological restoration and the management of remnant vegetation is a primary focus. We need to continue to promote the increased recognition among the broader Australian community of the inherent value and cultural significance of the flora. We also need to better sell the story of the work that many Australians are already undertaking to help protect and conserve our flora. At the same time we continually need to maintain our financial stability if we are to successfully achieve our goals. In saying this I feel we have gone a long way in addressing these challenges and we remain Australia's primary organisation for the promotion of plant conservation.

Workshops and outreach

This has been a busy year for workshops and we have continued to diversify our content to address the demand in various areas of interest. Eleven workshops were held with over 20 presenters and demonstrators, and a total attendance of 320 participants.

Four workshops were successfully rolled out over the last year thanks to Tricia Hogbin. Two plant identification workshops were held with the first "Plant identification for grassy ecosystems" in Canberra in March. This was the sixth and final workshop in our Jewels in the Landscape series, funded through a grant from the NSW Environmental Trust. The second was "Plant ID for Flora of the Wimmera" held in Horsham in October and supported by the Wimmera Catchment Management Authority and Landcare Wimmera. Tricia also coordinated a workshop on seed collection, storage and use for native vegetation restoration, supported by Ecologica consulting and the Australian Seedbank partnership and a workshop on translocation of threatened plants, supported by Ecologica consulting. Both were held on the Sunshine Coast, Queensland, in April.

Bob Makinson continued his marathon run with the Myrtle Rust workshops, running seven over the last year. Three workshops were held on Lord Howe Island in February with partners Royal Botanic Gardens Sydney, Office of Environment & Heritage NSW and the Lord Howe Island Board. Another four workshops were held in Western Australia, Perth, Bunbury and Albany in May with partners Royal Botanic Gardens Sydney Sydney, Department of Agriculture and Food WA and the Department of Parks and Wildlife WA (previously the Department of Environment and Conservation).

Tricia Hogbin commenced a project for the Royal Botanic Gardens Sydney contributing to development of the 'Restore and Renew NSW' project which aims to provide an easily accessible source of evolutionary, functional and environmental data directly relevant to the restoration of the NSW flora. ANPC's role is to:

- identify a list of 200–300 plant species considered 'most useful' in restoration projects across NSW;
- collate sources of information used to guide decision making regarding the provenance and fitness of plant material;
- identify stakeholders in restoration across NSW.

This has involved a number of outreach activities including an information Seminar in November, delivered in partnership with Royal Botanic Gardens Sydney and the Australian Association of Bush Regenerators and an online survey of species commonly used in restoration across NSW with 201 responses to date.

More broadly our outreach efforts expanded through a range of social media with the regular sharing of news and events in plant conservation via twitter, facebook, google+, and linkedin. The ANPC News email newsletter is now sent out once a month to over 760 subscribers.

Amelia Martyn presented a paper on behalf of the ANPC at the Australian Mine Rehabilitation Workshop in Adelaide, August 2013 on "*Recent advances in seed knowledge and techniques in the mining sector*". Amelia's presentation provided an overview of Australian research on seed sourcing and storage for restoration. The presentation was well received and provided an opportunity for future linkage between the mine rehabilitation workshops and ANPC training programs.

Our bulletin, *Australasian Plant Conservation*, has continued to publish high-quality articles relevant to a broad range of plant conservation practitioners and managers, under the editorship of Selga Harrington. Issue themes for the year have been: Value of plant conservation to animals; Fire and threatened biodiversity; as well as two editions with papers from ANPC's 2012 conference. Selga will step down from Editor's position and will handover to new editor, Huw Morgan, over the next two issues of APC - 22(3) and 22(4). On behalf of the Committee and all members I would like to sincerely thank Selga for her huge effort in ensuring that APC continues to be a quality and well respected publication for the communication of plant conservation issues in Australia.

To further develop our links with other organisations with similar objectives the ANPC became a member of the Conservation Council of Western Australia and we have also recently applied for membership of the ACT Conservation Council.

Conference

The 10th Australasian Plant Conservation Conference will be held the second week of November hosted by the Royal Tasmanian Botanical Gardens. A suggested primary theme is "Sustaining Plant Diversity - Adapting to a Changing World." Proposed themes are:

- Safe-guarding/Securing biodiversity (biosecurity, seedbanks, conservation genetics, restoration, corridors, climate change);
- Animals in plant conservation (pollination, dispersal, grazing effects);
- Prioritising actions (conservation triage, networking for cost effective outcomes, deciding approaches);
- Sustaining lives (biodiversity issues and food);
- Sourcing support (securing finance, community engagement, citizen science, project promotion in the digital age eg social media).

We expect to finalise these themes in early 2014.

Funding

Our financial situation was reported on in detail separately at the AGM but we continue to broaden our sources of income with this year producing a reasonable surplus, comparable to last year and an improvement on the previous two years where there were relatively small surpluses or deficits.

Workshop registrations were a key source of income with the Myrtle Rust workshops a significant component. We were also successful with grants from the NSW Environmental Trust's Lead Environmental Community Groups; the Department of Environment Grants to Voluntary Environment, Sustainability and Heritage Organisations and the Hunter Central Rivers Catchment Management Authority Capacity Building Program.

We have applied for a number of grants that have yet to be announced: the Department of Environment Grants to Voluntary Environment, Sustainability and Heritage Organisations, the NSW Environmental Trust's Restoration and Rehabilitation Community Grants program and the NSW Environmental Trust's Lead Environmental Community Groups grants. We also applied unsuccessfully for funding from the NSW Environmental Trust's Environmental Research Program and the Australia Korea Foundation (DFAT). While unsuccessful a number of these grants were developed up as partnerships with the Australian Seedbank Partnership and Greening Australia, and both organisations are keen to partner with ANPC in the future.

We have received in-kind contributions towards workshop delivery from Ecological Consulting and the Australian Seedbank partnership and its member organisations (plus presenter volunteer contributions) and sponsorship of workshops from the Wimmera Catchment Management Authority and Landcare Wimmera.

Staffing

The ANPC has had a number of staff changes during the year. Merryl Bradley retired as Business Manager in June this year although Merryl has continued to work closely with the Committee as Acting Treasurer with Adrian Fethers stepping aside. Merryl has and continues to make a major contribution to the ANPC and I have greatly appreciated her support and help not only as Business Manager but also as the acting Treasurer.

In June ANPC welcomed our new Business Manager, Jo Lynch to replace Merryl Bradley. Jo's background is in bush regeneration and weed management in the Sydney region. Jo is delighted to be joining the ANPC and will be working on increasing the organisation's profile and funding through grants, donations and sponsorships, as well as a few other new ideas. Her vision is for the ANPC to grow in size and influence to equal other major national environmental organisations. We also recently welcomed our new Office Administrator Carly Westbye. Carly's background is graphic arts and desktop publishing. She has worked in both the public and private sector. Carly is looking forward to sharing her skills and knowledge in the print and publishing industry, along with providing critical administrative support.

I am again grateful to Committee members for their tremendous support over the year. They have significant commitments outside the ANPC and it is sometimes challenging to devote the time that they do in maintaining active participation as a committee member. The involvement in the committee by all Committee members is a clear demonstration of their dedication to the ANPC and its goals in improving plant conservation.

Special thanks to departing Committee members Phil Collier, Paul Donatiu, Sally Jacka, and Noushka Reiter and to Treasurer Adrian Fethers. They have all made major contributions during their period on Committee. On behalf of the ANPC membership and fellow committee members I wish them all the very best and hope that despite their departure from the committee they continue to remain active within the organisation.

The coming year

A number of workshops are already in the planning stage for next year. The ANPC recently received funding from the Hunter-Central Rivers CMA to deliver a workshop in March 2014 on seed collection, storage and use for native vegetation restoration.

We have commenced the review of our Strategic Plan as a precursor to the drafting of a new plan. We received 57 responses to a Strategic Plan review survey and many thanks to those of you who responded. Overall the vast majority of responders supported the various aspects of the current Strategic Plan. There were also quite a number of comments and suggestions and these will be taken on board as we progress drafting in 2014.

Significantly we have started planning for the re-development of our website to be completed next year and the publication of an ANPC Prospectus to seek new funding and sponsorship opportunities from relevant companies and organisations.

Finally there is our 10th Australasian Plant Conservation Conference to be held in Hobart in November. This is the ANPC's primary event and we hope this conference will be of great interest to all members and many others with a key interest in plant conservation in Australia

Are seed banks misunderstood? A perspective from the Millennium Seed Bank

Paul Smith

Royal Botanic Garden, Kew's Millennium Seed Bank, London UK; Email: p.smith@kew.org

Aims of Kew's Millennium Seed Bank

The Royal Botanic Garden, Kew's Millennium Seed Bank (MSB) opened in 2000. It is a global seed bank for wild plant species at the centre of a Partnership comprising around 170 partner institutions in 80 countries. It has two main aims up to 2020:

Target 1: to secure in safe storage 25% (75,000) of the world's plant species, prioritising rare, threatened and useful plants.

Target 2: to enable innovation, adaptation and resilience in agriculture, horticulture, forestry and habitat restoration.

The Millenium Seed Bank visitors centre. Photo: Royal Botanic Gardens, Kew

Influencing public perception

Ever since the Millennium Seed Bank was built in 2000 we have had to expend considerable time and energy explaining that seed banks are not just 'doomsday vaults' in which seeds are held in case of a major emergency. This has been a delicate process because there is no doubt that for many of our supporters the insurance against extinction idea is compelling – and, of course, *it is* an important role that seed banks play. The problem with emphasising the risk of extinction and predicting dire consequences for humanity if plant species become extinct is that too much doom and gloom generates apathy – a feeling of inevitability and that this is too big for us to do anything about.

Setting clear targets

One of the ways that we have tried to turn the conservation role of seed banks into something more positive has been to promote the message that there is no technological reason why any plant species should become extinct. We don't say that seed banks are the entire answer but we say they are part of the solution – particularly for those plant species that cannot be conserved *in situ*. This has the positive effect of persuading people that something can be done. Furthermore, we can make that something tangible by setting milestones such as 10% conserved by 2010 or a quarter of species banked by 2020.

This approach also has its problems, however. For one thing, the number of plant species in the world keeps growing. In 2000 when we set the 10% target for the Millennium Seed Bank Project, it was estimated that there were 242,000 plant species on the planet. Now that figure has increased to around 370,000, and it is still rising. In addition, not all seeds can be conserved in an orthodox seed bank at low humidity and temperature – current estimate are that as many as 20% of the world's vascular plant seeds are desiccation intolerant. Most importantly, a percentage figure means nothing in conservation or scientific terms. We should be prioritising the rarest, most threatened and most useful plant species for seed conservation, not just a random number. Despite this, we do still promote percentage milestones because this strikes a chord with the public – ambitious, positive and – best of all – measurable.

Funding sources

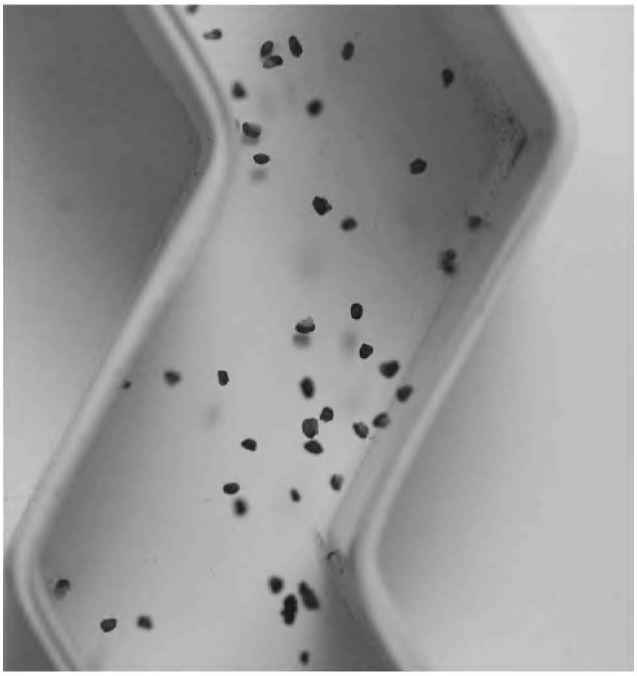
Of course it is not just the general public that we need to persuade about the value of seed conservation. We also need to make the case to funders. Currently, about 40% of MSB funding comes from the UK Government with the remaining 60% coming from a range of other sources – primarily, trusts, foundations and individual donors. In the past, agriculture, forestry and horticulture seed banks have been government-funded infrastructures. This is primarily because in the crop breeding value chain, the public sector carries out the collection, characterisation and supply of a wide range of plant diversity to the private and academic sectors for further research and development. Over the past three or four decades, however, western governments have increasingly disinvested in public sector infrastructures – particularly in agricultural research – leaving this to the private sector or to academia. This particular problem has been exacerbated by the financial crash of 2008. In addition, it is difficult to persuade democracies with frequent changes of government to think in the long term – as evidenced by recent attempts to get international action on climate change. This means that governments are behaving more like our other funders - foundations and individual donors. All want an immediate return on their investment, and usually their particular interest will be specified – human health, livelihoods, forests, food security etc.

For these reasons, we have found it more productive to emphasise the important role that seed banks play in providing high quality seeds for innovation and adaptation. This takes us firmly away from the doomsday vault idea and instead concentrates on the idea that seed banks create opportunities. To this end, as mentioned above, the second target of the Millennium Seed Bank Partnership is '*to enable human innovation, adaptation and resilience in agriculture, horticulture, forestry and habitat restoration'*. This is a much more positive message and starts to bring in the idea that there is a more immediate return on investment for people.

Case studies on the monetary value of seeds in the seed bank

Most rare and threatened species have no particular use to people, and they certainly don't have a monetary value that you can define. Instead, we have had to choose particular case studies for subsets of our collection and how they are used. We have publicised two such case studies recently.

The first case study involves Japanese Knotweed (*Fallopia japonica*), an invasive weed, that costs hundreds of millions of pounds a year to control in the UK, and yet it continues to spread. CAB International (Commonwealth Agriculture Bureau International) recently developed a biological control for Knotweed, and in order to gain a licence to release the control agent (a beetle), they needed to test it against UK native species to make sure that it was specific to Fallopia. The MSB supplied CABI with 48 seed collections of native plants, including highly threatened species. None were found to be susceptible to the beetle, enabling CABI to release the control at least a year earlier than would have been possible without ready access to this material. The London School of Economics has calculated that, depending on the efficacy of CABI's biological control, the potential value of the material supplied by the MSB is between £27 million and £121 million.



The automated winnower quickly separates out all the unwanted plant material. Photo: Royal Botanic Gardens, Kew

The vault where the seeds are carefully stored. Photo: Royal Botanic Gardens, Kew

The second case study looks at crop wild relatives. The MSB co-manages the *Adapting Agriculture to Climate Change Project* with financial support from the Norwegian Government. The purpose of this project is to collect, conserve, characterise and make available to plant breeders crop wild relatives (CWRs) from 29 of the world's major crops, including wheat, rice and potatoes. By 2020, the MSB and the Global Seed Vault in Svalbard will hold the most diverse and comprehensive collection of CWRs in the world. CWRs contain useful genes and traits (e.g. for drought tolerance, disease resistance and increased yield) often absent from domesticated varieties, and represent an important resource for plant breeders developing new varieties in a changing climate. In a study commissioned by Kew, Price Waterhouse Coopers estimate that the value of new CWR-derived varieties of those 29 crops over the next 10 years is approximately $120 billion.

Using this case study approach, we are hopefully able to win the argument that seed banks make financial sense. However, once you start to fling billion dollar figures around, funders ask the question 'Well, if these seeds are worth so much money, surely you can charge people to use them or demand royalties?' We then have to explain that these seeds are collected under the Convention on Biological Diversity or the International Treaty with strict conditions. One of these conditions is that we don't charge for their use. This is completely baffling to many in the private sector, and sadly the same is true to many in government where the idea of a public good is no longer fashionable. And so we battle on…….

Historic seed collections germinated for the Australian PlantBank opening

*Monica Fahey [1,2], Amelia Martyn[2] and Cathy Offord[2]**

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Introduction

Since the establishment of the Royal Botanic Gardens and Domain Trust (RBG) in Sydney in 1816, seeds have been an integral part of the collections. Seed and plant distribution was seen as an important role of the RBG in the establishment of the European colony of Australia (Aldous et al. 2011). In 1881 the large State Nursery was established at Campbelltown which, over its 50 year history, was responsible for growing and distributing hundreds of thousands of plants of both native and exotic species. Charles Moore (director – 1848–1896) was considered *'instrumental in introducing the Jackaranda [sic], Pepper tree and Hibiscus to Australia'* (Gilbert 1986). The first official seed exchange catalogue was distributed in 1883.

In the fashion of Victorian times, Charles Moore, followed by Joseph Maiden (1896–1924) developed a botanical museum at the Royal Botanic Gardens Sydney, housed in what is now the 'Moore Room'. By 1900, there were over 7000 listed items of economic or ethnobotanical importance, including seed samples of many species from Australia and around the world. The annual report of the Gardens from 1902 shows hundreds of seed samples making their way into the living collections of the Gardens and museum ('1047 seed packets received, 2760 packets despatched mostly New South Wales seeds'). The museum was disbanded following WWII and today, only a proportion of the collection remains. The seeds were kept mostly in small corked, specimen bottles and housed at room temperature in a rather humid basement of the RBG, conditions that are sub-optimal for maintenance of seed viability.

Vial of 114 year old Acacia obtusata *seed from the museum collection, and germinants from the museum collection. Photo: Jaime Plaza, Royal Botanic Gardens and Domain Trust*

Seed collection and storage technology has moved on considerably since the botanical museum was disbanded. To highlight this, and to coincide with the opening of the Australian PlantBank in October this year, we attempted to germinate some of the museum seed collections. Most collections were made between about 1880 and 1920, making the seed collections up to 132 years old.

Germination experiments

A range of Australian native and exotic species from the remaining collections of the museum were transferred from the Royal Botanic Garden Sydney to the Australian Botanic Garden, Mount Annan in 2012 and germination tests were carried out on 108 collections in 2013. Collections were chosen based on their potential longevity and appearance. Labels on some collections included a date (likely to be the date of collection or cataloguing), collection location and collector, but others only included a species name.

Seeds were treated using routine procedures of the Australian PlantBank: 10–30 seeds were incubated on 0.7% water agar at 20°C with 12 hour of light. A scarification pre-treatment was applied to all species, based on experience with recent collections of the taxon. In addition, gibberellic acid (a plant hormone promoting germination) was incorporated in water agar (250 ppm) for *Rulingia pannosa*. Experiments ran for at least 19 days and were ended when seeds went mouldy.

Results

Seeds of eight species (nine collections) germinated (8% of the tested collections germinated), from the Fabaceae, Sapindaceae and Malvaceae families Seedlings were potted up and are growing in the nursery for further evaluation of vigour.

Museum collections successfully germinated

Family	Species (current name)	Description	Germination
Fabaceae	*Acacia obtusata*	Collected from Barbers Creek. Date on vial of seeds 5/1899. Likely to be same collection as herbarium specimen NSW 156229, collected by JH Maiden, with illustrations of fruits, leaves and flowers by Margaret Flockton for 'The Forest Flora of NSW'.	58% after 5 days
Fabaceae	*A. prominens*	No date on vial or collection info.	4% after 14 days
Fabaceae	*A. pubescens*	Date on vial of seeds 11/1897. This is now a threatened species and rarely sets seed.	4% after 5 days
Sapindaceae	*Dodonaea camfieldii*	Date on vial 11/1897.	10% after 7 days
Sapindaceae	*D. filiformis*	Date on vial 3/1898, collected from Tasmania. Name on vial '*Dodonaea ericifolia*'.	3% after 28 days
Sapindaceae	*D. viscosa*	Note on vial 'Saharanpur'. Saharanpur is a city in India. *D. viscosa* is widespread in Australia and also occurs in regions of Africa, the Americas, southern Asia and Australasia.	4% after 7 days
Malvaceae	*Rulingia pannosa*	No date on vials. Name on vial '*Commersonia dasyphylla*'.	25% of one vial after 7 days, and 5% of second vial after 5 days
Malvaceae	*Sida corrugata*	Collected from South Australia. Date on seed vial 10/1897. This widespread species grows in the Cumberland Plain Woodland at Mount Annan and is growing in the Plantbank garden beds.	10% after 7 days

Significance of results

As expected, seeds of most collections tested did not germinate (contact authors for species list), consistent with other studies on seeds stored over long periods in sub-optimal conditions (Godefroid et al. 2011). Although we don't know if these species were initially viable following collection, we assume this to be the case. The lack of germination certainly indicates that these seeds are no longer viable.

Seeds did germinate from plant families where we expect seeds to be long-lived, based on previous research (Gunn 2001, Offord et al. 2004, Merritt et al. unpublished data). Hard-seeded Australian species adapted to our hot, dry environments are known to be the longest-lived in the world (Probert et al. 2009). Seeds of the family Fabaceae are well-known for their extreme longevity, but reports of long-lived Malvaceae and Sapindaceae are less common in spite of their hard seed coat (but see Telewski and Zeevaart 2002). Seeds of these species stored in conservation seedbanks like the Australian PlantBank are expected to have a lifespan of thousands of years, and even under sub-optimal storage conditions may survive for more than a century. However, other Australian species have a much shorter lifespan in storage and require stringent conditions of low humidity and low temperature to extend their longevity.

The germination of these historic seed collections demonstrates that:

- seeds of some Australian species are adapted for extreme longevity;
- fermplasm of native species can be preserved, ideally in conservation seed banks but sometimes even under sub-optimal conditions, with consequences for retrieval of extinct species or ecotypes;
- seeds of historic collections, including herbarium specimens, may have the potential to germinate and require cool, dry, pest-free storage conditions to maximise their lifespan.

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Meeting the seed needs for future restoration

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Introduction

Revegetation of complex native vegetation, particularly by direct seeding, is now seen as technically feasible (e.g. Gibson-Roy et al. 2010). However the reconstruction of complex communities requires large amounts of seed from a broad range of species and functional types. In the last decade, there has been some change in perception regarding the feasibility and desirability of complex ecological restoration, both at a practitioner and funding level. There are now an increasing number of restoration projects aiming to reconstruct complex native vegetation. With this development has also come a gradual and continued development of the seed sector to meet the requirements for seed and expertise.

There are now seed producers in most states, including private, not-for-profit, community and Landcare groups. Together they are helping to meet market demand for seed in reliable quantities and quality using various combinations of horticultural and agronomic techniques. Seed production is especially important as it helps to lessen the impact of seed harvest on remnant populations and goes some way towards ensuring a reliable supply of common species. Field harvest remains an important component of the sector, not only for the propagation of plants (especially trees and shrubs) but also for establishing founder production crops.

Field collection

Mechanical harvest

For restoration programs using mechanical seed delivery (seeders) large seed volumes will usually be required, particularly for grasses. Where local populations/stands are available, mechanical harvesting using brush or vacuum-type harvesters can deliver seed volumes at the scale of wool bales rather than paper bags, which is the case for hand collection. While time and labour are still required to 'scout' for seeding populations, mechanical harvest can dramatically reduce the time and cost, and increase harvest volume in comparison to hand collection.

Depending on the configuration of harvester many species can be mechanically harvested; including grasses, daisies and many other wild flowers. In the field (as opposed to production settings) species-specific mechanical harvest is difficult, where species are growing among one another. However, species mixes can be harvested in these settings, targeting those that are seeding at the time of harvest. These mechanical harvests can be processed and used as seed or left unprocessed and used as 'seed hays'. Mechanical harvest will also exclude seed held below the height of the harvester. It should be noted that there is a high probability of inadvertently harvesting the seeds of weed species growing within the community. Once weed seeds have contaminated a harvest they are extremely difficult (and costly) to remove and this is an important reason why ideally, mechanical harvesting targets well-managed remnant, reconstructed or production sites which are dominated by native species.

Harvesting by hand

Hand harvest is very useful for selectively targeting individual species that are widely dispersed within a larger community. While it can be time consuming and at times difficult work, hand harvest allows for close scrutiny of plant identity and for assessment of seeds and fruits for ripeness. It also helps to avoid, although never completely,

Grass seed production by David Franklin, Chatsworth south western Victoria. Photo: Paul Gibson-Roy inadvertent weed contamination. Hand harvest is commonly used when to the aim is to harvest relatively small amounts of seed for plant propagation of tube stock or to initiate production populations.

Seed production

It is now commonly accepted that the cultivation of plants as seed crops, using established agronomic and horticultural techniques, reduces collection pressure on local populations and allows for greater control over the quality of harvested seed.

Native grasses were early candidates for seed production for grassy ecosystems because they are common and often dominant and for their value in farming (e.g. fodder, soil stabilization). In 2006, Cole and Johnson published a comprehensive review of issues related to the cultivation of Australian native grass cultivars for seed production. Seed production is ideal for producing the quantities of grass and wildflower seed required for sowing substantial areas of land. It requires well-managed field crops, appropriate levels of labour and infrastructure (e.g. sheds, machinery, irrigation).

Genetics

Regardless of the system, seed productions should ensure that the harvested seed for any species retains the genetic structure of the source population. This assumes the production crop was propagated and grown from seed that captured the genetic diversity of the source population/s. This being the case, to reduce the impact of inbreeding during the production cycle, crops should routinely be replaced or supplemented with new plants grown from wild-harvested seeds (rather than from seeds produced in cultivation). General experience has been to replace container crops after one, or at most two, harvest seasons. Another issue that may arise in seed production is hybridization. To avoid hybridization of related crops (genus or species) crop populations should be isolated from each other in space or time.

In-ground matted seed production by City of Salisbury, Adelaide South Australia. Photo: Paul Gibson-Roy

Large field crops of perennial grasses are commonly grown and maintained for several seasons; depending on seed output and provided weed control is adequate. To increase the understanding of protocols that aim to preserve the genetic attributes of source populations in production, there is a need for research to compare the genetic diversity in seed lots harvested from cultivated crops after one or more generations, with that of the initial wild harvested seed. However, given the numbers of species currently used in production, and the expense of detailed genetic investigations, the precautions outlined should be followed until more information is available.

Seed quality

Many herbaceous species have rarely, if ever, been harvested commercially or used in restoration programs. For most seed collectors working with an unfamiliar flora, recognizing mature inflorescences and filled seed is often a challenge. In such instances the harvest of empty and immature seeds reduces the quality of their harvest and can impact on the confidence of buyers or on seed end-use outcomes.

For this reason, it is important that there is some understanding of the quality characteristics of seed prior to its sale or use. While some seed testing laboratories have access to a range of sophisticated testing methods, most users of seed have limited access to these facilities. However, there are a range of relatively simple and cost effective methods that can be undertaken in most nursery settings that can measure quality of seed, including:

- proportion of pure seed of the target species;
- presence of seed from non-target species;
- proportion of other materials in the sample (i.e. plant parts other than seed, soil, fungal bodies, insects);
- germination capacity of a test sample.

Conclusion

Seed is the single most fundamental resource required for effective plant community restoration. Ideally it is of high quality, weed free, affordable and available in appropriate volumes. To meet these goals will require vision, planning and the combination of multiple techniques and disciplines. Only in this way will we meet the seed needs for future restoration.

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Seed production project produces translocation spin off for a highly threatened species

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Introduction

Temperate native grasslands and grassy woodlands are among Australia's most threatened plant communities and include many individual species that are highly threatened. Among barriers to retaining threatened communities and species are scarcity of source populations, lack of seed resources, intense competition from weed species and unsuitable disturbance or management regimes.

Encouragingly, restoration (particularly by direct seeding) is now perceived as a technically feasible means to restore complex communities and/or re-establish populations of threatened species (e.g. Gibson-Roy et al. 2010). An important component of these new techniques is the use of seed production to supply appropriate quantities of seed for restoration.

The Ginninderra Peppercress

Ongoing support of seed production and complex restoration techniques have recently been applied in the ACT by the Australian National Botanic Gardens (ANBG) and Greening Australia, as part of a broader program to grow seed of grassland species to support ongoing restoration of these threatened communities.

Among the species chosen for propagation and translocation under the program is the Ginninderra Peppercress (*Lepidium ginninderrense*). This member of the Brassicaceae – a perennial herb growing to about 20 cm – is one of the ACT region's most threatened species and is nationally listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Ginninderra Peppercress is not known from outside the ACT and is believed to have declined as a result of modification and destruction of its grassy habitat. The type locality population occurs in the north-west corner of the new northern Canberra suburb of Lawson, on the floodplain of Ginninderra Creek in Natural Temperate Grassland. The site was estimated in May 2000 to contain approximately 2200 plants across an area of 90 x 30 m although more recent data indicate significant annual fluctuations in numbers. In 2012 a second population of about 50 plants was discovered in the northern Canberra suburb of Franklin, in an 18 hectare patch of grassland and woodland reserved from suburban development.

An individual Ginninderra Peppercress ready for planting. Photo: Australian National Botanic Gardens

As the population in Lawson is confined to one small area of less than 3000 m^2 on a floodplain, a single catastrophic event such as flood or fire has the potential to destroy or seriously impact the population.

The propagation story

During an Australian Network for Plant Conservation course on the conservation of ecological communities in 2002, Joe McAuliffe from the ANBG and Sarah Sharp (then Senior Vegetation Ecologist for the ACT Government) wondered whether establishing a seed production program for the Ginninderra Peppercress might be possible. That initiated a wider discussion which resulted in a plan to address the potential for recovery action for this species.

The following summarises the subsequent sequence of significant events:

- a project plan was scoped;
- seed from collections made by the ACT Government five years previously were received at the ANBG for seed banking and propagation – the seed had no suitable

storage history and tests resulted in zero germination, potentially indicating a seed longevity period of less than five years under ambient conditions;
- in consultation with Greg Baines (ACT Government) the ANBG collected a small amount of fresh seed in the summer of 2008. From this collection, 50 plants were grown successfully, from which a small pilot study was set up to determine if a larger seed production program could be achieved.

The pilot study produced some interesting results:

- plants grew vigorously, flowered and fruited with resulting seed proving to have high fecundity;
- production of 200 seeds from each individual grown in optimal conditions within the ANBG Nursery was possible over a six month growing period, ideally from October to March;
- ripening of seed capsules and consequent seed set appeared to rapidly progress four days after the occurrence of high daily temperatures (+30°C) – this result assisted us to successfully target and time our seed collection from the wild population.

Overall, the results of the pilot study gave us the confidence and experience to streamline production and cultivation methods.

Seed collection from the wild population

Collection of seed from the wild population commenced on 30 November 2011. We surveyed the entire Lawson site and found 406 individual plants. As our collections permit allowed us to collect 10 per cent of the available seed set, the total amount of seed to be collected from any individual was limited to 20 seeds.

A small number of wild plants appeared to have poor growth habit with poor flowering and fruiting and seed was not collected from those plants. Of the 406 individual plants found, 20.6% did not produce viable seed.

In 2012, 1589 individual plants (from the 332 wild collections made in 2008) were grown for seed production. Having tested the seed collection and propagation techniques, efforts were aimed at securing a minimum of 100,000 seeds from these plants for research and reintroduction.

Outcomes from this work include:

- over 200,000 seeds of Ginninderra Peppercress are now stored in the National Seed Bank (dried under conditions of 15 per cent relative humidity and 15°C and now banked at –20°C);
- germination testing after four years of storage under these conditions resulted in 100% viability and germination;
- as one tool in the *ex situ* conservation of Ginninderra Peppercress, seed banking under appropriate conditions is a cost effective and efficient means of ensuring the species' genetic diversity;
- a genetically diverse population was established by maintaining 'mother plant lineage', this means that we can track the ancestral history of every individual to its initial mother plant from the first seed collection event;
- detailed recording of information for the propagated plants, from herbarium history to field collecting to clonal lineage through propagation and seed collection through to the land management receivers of new plants.

The 2013 translocation project

In September 2013 a translocation was undertaken establishing new populations at two new secure locations, in two ACT grassland nature reserves. Coordinated by Greening Australia with the support of an ACT Environment grant, the 1589 seed production plants were translocated. The two community planting events enabled 65 volunteers and government staff to be involved with the final step in securing two more wild populations of this easily overlooked grassland species.

These new plantings now represent the largest populations of this species in the wild and complement the 200,000 seeds already banked from the seed production area project. The conservation outcome for one of the region's most threatened species has been greatly strengthened and, with all documentation and history transferred to new custodians, there is a sound basis for its ongoing protection.

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Land managers, project partners and volunteers planting a new population. Photo: Australian National Botanic Gardens

Germination of the endangered species Port Lincoln Speedwell in response to season and fire cues

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Introduction

Port Lincoln Speedwell (*Veronica parnkalliana*) is listed as an endangered species and is endemic to South Australia. It was first recorded from the Eyre Peninsula in 1909. It is described as a perennial herb, bearing erect to ascending branches from 20–40 cm high. The leaves are opposite with serrated, tooth-like margins and it has attractive white flowers with purple striations in the centre of the petals. The plant was not recorded again until three consecutive records from 1984 to 1986 were made in the southern Flinders Ranges. Port Lincoln Speedwell was recorded more recently after a targeted search of a fire scar in the Mount Remarkable Conservation Park in the spring of 2008. Large numbers of viable seed were collected in the summer of 2008 and are currently in long-term storage in the seed bank at the South Australian Seed Conservation Centre. However, to safeguard this species from extinction, it is important to understand its seed biology, and to determine successful germination methods to enable reintroduction.

The sighting of this endangered plant post fire indicated that Port Lincoln Speedwell may belong to the group of plants known as fire ephemerals. These plants are generally short-lived and germinate mostly after fire, producing seeds that persist in the soil seed bank between fire events (Baker et al. 2005). Seeds remain dormant in the soil and germination is stimulated by components of fire rather than in response to soil moisture or seasonal changes. Triggers for germination in fire ephemerals include heat and smoke, which may be required separately or simultaneously to promote germination.

The seed biology of Port Lincoln Speedwell was investigated using in vitro germination experiments and in situ burial throughout an annual cycle. Seed germination was tested at three monthly intervals to determine whether burial through seasonal changes had any effect on the dormancy state. The main aims of this study were to determine how the initiation of germination is affected by temperature, season, and fire.

Germination after *in situ* burial and response to heat and smoked water treatments

Seeds were collected from Mt Remarkable in December 2008 and maintained in storage at 15°C and 15% relative humidity until use. Initial *in vitro* germination tests showed that seeds had a high level of dormancy with no germination recorded in the presence of sufficient water over a range of temperatures. However, high levels of germination (80 to 90%) were observed after treatment with the plant hormone gibberellic acid (GA_3). Germination capacity, in the presence of GA_3, was assessed using a range of temperatures generated by a thermogradient plate. Optimal temperatures were found to be between 10°C and 18°C. Germination levels declined at temperatures over 20°C, with no germination recorded at 30°C or above.

The seed embryos were linear and underdeveloped, which indicates that the embryos need to grow within the seed before germination can occur. Seeds within this classification often respond to the application of GA_3 and have been shown to have seasonal cyclic dormancy that may be affected by periods of cold or warm then cold stratification (Ooi et al. 2007). Several reports have suggested that seed burial has an effect on dormancy and germination initiation (Baker et al. 2005, Ooi 2010). To test the response of Port Lincoln Speedwell, seeds were buried at four sites at Mt Remarkable Conservation Park within the vicinity where the population was observed growing. A sample of seeds was exhumed at the end of each season and tested for seed viability using a vitality stain (tetrazolium chloride). Germination experiments were set up with several treatments including GA_3, smoked water, dry heat and a combination of smoked water and dry heat.

The results of the experiment show that a high percentage of seed viability was maintained throughout the burial period, although a slight decline was observed throughout the year. The germination results from seeds treated with GA_3 also confirm that seed viability remained high as the mean germination levels were above 75%. In contrastz germination levels in the untreated control seeds were negligible throughout the burial experiment. This shows that Port Lincoln Speedwell seeds have a high level of dormancy that is overcome in the presence of GA_3. The seeds also responded to both the heat and smoked water treatments, resulting in an increase in germination compared to the control. Heat and smoked water treatments had a synergistic effect as germination increased when both of these fire components were applied.

The pattern of germination over the year revealed that fire components stimulated germination after burial during summer and spring. However, there was no response from seeds following burial throughout autumn and winter. This change in response has been reported for seeds with cyclic dormancy, where seeds are responsive to certain environmental cues and cycle through periods of dormancy depending on the season (Baskin and Baskin 2004).

General discussion

Factors leading to germination may include stratification at different temperatures, and/or after ripening to alleviate dormancy. However, these results showed that germination did not occur after burial alone and that treatment with GA_3, smoke or heat was necessary for germination to be initiated. The cyclic dormancy pattern observed changed through the warm and cool seasons. Seeds responded to fire cues in December and March, at a time when bushfire is likely to occur naturally. The likely circumstances under which Port Lincoln Speedwell enters the vegetative stage of its life cycle can be deduced using the data obtained from both the field and the laboratory. We propose that fire during the warmer months, delivers the fire cue to the seeds at a time when dormancy is alleviated. Germination would then occur when moist conditions were maintained by sufficient rainfall and temperatures were conducive to germination (below 20°C). These conditions would occur during winter resulting in plants growing and flowering during spring with seeds ripening during early summer.

Broadening the understanding of the seed biology of our threatened plant species increases our ability to monitor biodiversity and restore habitats. Identifying Port Lincoln Speedwell as a fire ephemeral species provides the opportunity to predict the emergence of this species with more accuracy. These results provide new insight into how the interplay of environmental conditions affects the life cycle of this species.

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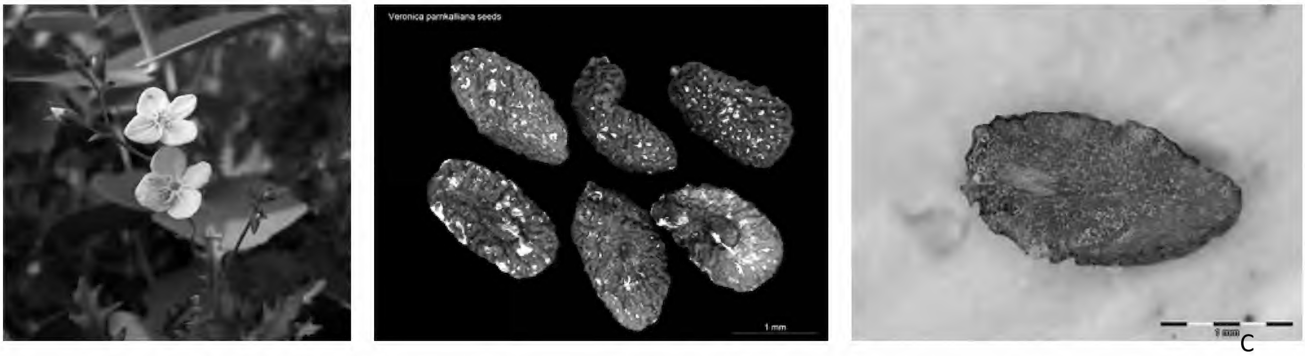
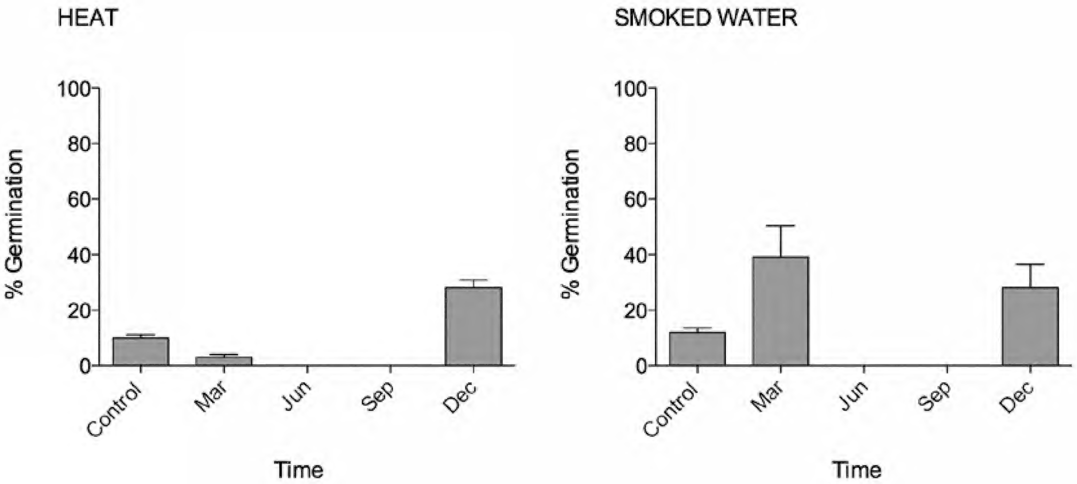


(Left to right) Flower buds and leaves. Seeds. Longitudinal cut of the seed showing the underdeveloped embryo.
Photos: South Australian Seed Conservation Centre



Germination data from the in situ *burial experiment. Seeds were exhumed at the end of each season and tested for germination with different treatments. Viability was determined using a tetrazolium chloride stain.*

A comparison of germination stimulants applied to five difficult to germinate native species from Queensland

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Introduction

An almost universal characteristic of seeds is a resting phase known as 'dormancy' which must be broken before germination can proceed (Pate and McComb 1981). Native Australian plant species often possess both physical and/or physiological dormancy, due to their adaptation to climatic factors which enhances their survival in the soil seed bank. In an Australian context, seeds have adapted to harsh and variable environments to take advantage of the few opportunities for plant recruitment – as with the flush of germination after fire for example.

In order to germinate a seed, it is necessary to first define the type of dormancy and then determine the conditions necessary to alleviate the dormancy (Turner and Merritt 2009). Seed coat dormancy has been suggested to act to prevent germination and can include the mechanical restriction of the expanding tissues, (i.e. hard seed coat or testa), the presence of germination inhibitors in these associated structures, or an impermeable barrier to the passage of liquids and gasses moving in or out of the seed (Adkins et al. 2005). This can pose problems for both researchers and industry practitioners alike, as a reliable and effective methodology for the germination of native plant species, can be essential for both cost effective and successful germination outcomes.

Five difficult to germinate native species from Queensland, as proscribed by the Seed Conservation Department of the Millennium Seed Bank, Royal Botanic Gardens, Kew, U.K., were subjected to the germination stimulants potassium nitrate, gibberellic acid and smoke water, in order to test their relative effectiveness in promoting germination in these species.

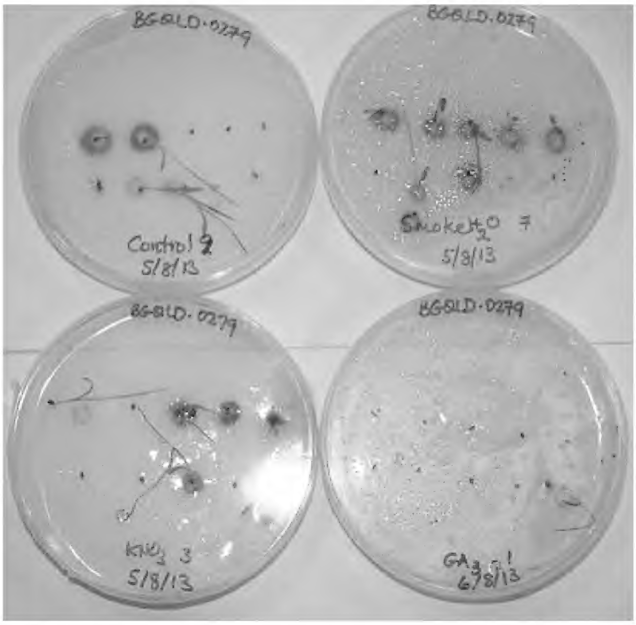
Materials and methods

Seeds of five native Queensland species, *Petalostigma triloculare* (Quinine Bush), *Trachystylis stradbrokensis*, *Panicum simile, Melaleuca monantha* and *Melaleuca pallescens*, stored at 5% moisture content and –20°C for 12 months, were brought to ambient temperature. Potassium nitrate (KNO_3) and gibberellic acid (GA_3) (at concentrations of 101 mg/l; 250 mg/l respectively) and a 10% solution of smoke water ("regen smokewater" from Grayson, Australia), were applied at 20°C for 24 hours prior to germination testing. Four replicates of 25 seeds each were used for each species and each treatment (control, potassium nitrate, gibberellic acid and smoke water). The larger seeds of *Petalostigma triloculare* were surface sterilised using a 1% concentration of sodium hypochlorite.

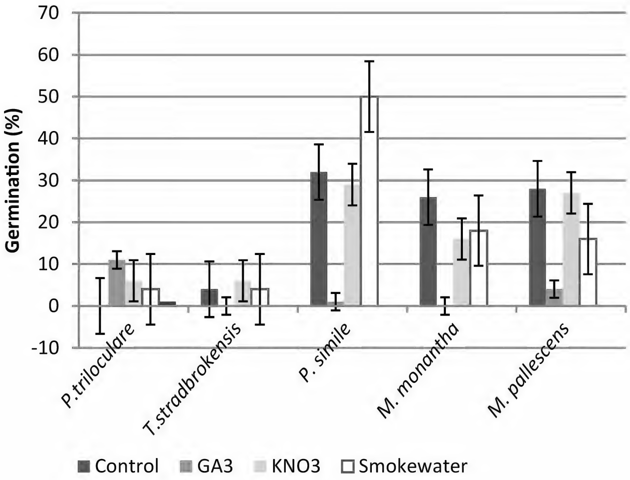
Following pre-treatment, seeds were placed onto 1% water agar in 90 mm Petri dishes and incubated in a germination cabinet with an 8/16 hour photoperiod and alternating day/night temperatures of 28/20°C.

Results and discussion

Seeds were scored for germination on a weekly basis, with germination defined as the emergence of a radicle (first part of a seedling to emerge from the seed during germination), of 2 mm or greater.

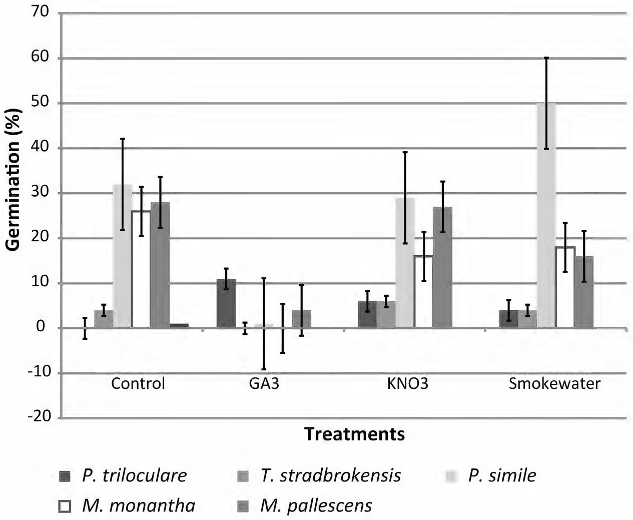


Germinants of Panicum simile. *Photo: P. Cameron*



Percentage germination of seeds (±S.D. 12.6) of five native species: comparing species response after 8 weeks to different germination stimulants.

A statistical analysis of the data using a χ^2 distribution and a significant difference ($P<0.05$) indicates that between the germination stimulants the numbers of germinants varied considerably particularly with the use of smoke water, which significantly increased the numbers of germinants in respect to *Panicum simile*. Interestingly, giberrellic acid had a very limited affect on the germination of all species over this period. It was thought that an error might have occurred with the dilution ratios; however, as the experiment was staggered, the dilution ratios were repeated with exactly the same results.



Percentage germination (±S.D. 12.3) of seeds of five native species: comparing responses for control and three germination stimulants after 8 weeks.

For four of the species (*P.triloculare, T. stradbrokensis, M. monantha* and *M. pallescens*), none of the germination stimulants significantly improved germination beyond control levels and gibberellic acid decreased germination in four of the five species.

The application of smoke water was shown to be very effective in one of these five species (*Panicum simile*), which could well be an indication of the physiology and ecology of this particular species. While there is little known about how the smoke acts upon the dormant seed to promote germination, it is possible that smoke acts, in at least one way, to scarify the impermeable seed tissues, thus allowing the transfer of water and oxygen to facilitate the germination process (Egerton-Warburton 1998). Further work is required to improve germination in the remaining four species.

Vleeshouwers (in Obendorf 1996) asserts that seeds do not passively wait for the correct environmental conditions to germinate. Rather they are constantly adjusting their degree of dormancy as a reaction to the environment they are experiencing and have experienced during seed development and maturation on the mother plant. Hence, knowing the provenance of the seed being tested may give indications as to the degree or depth of dormancy that a seed is undergoing (Obendorf 1996).

It would seem from these results that each individual species has a very unique response to each germination stimulant, and that only through more experimentation will an understanding of the mechanisms involved in germination be properly understood.

Acknowledgements

Thanks to Jason Halford for his tireless collection of native species for the 'Seeds for Life' seed conservation program, and Dr Sarah Ashmore, Griffith University, for some suggestions regarding the text.

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Brief notes on *Baeckea kandos*, a highly restricted endemic from Wollemi National Park

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Introduction

Baeckea kandos, listed as endangered under both federal and state legislation, is a woody shrub described as reaching a height of 2 m. The oil gland dotted leaves are linear to linear-oblanceolate, 4–6 mm long and 0.6–1.0 mm wide. The young branchlets are pink and somewhat pendulous. It bears small white flowers to 5 mm diameter in December – January. Until recently it was known from only two locations a few hundred metres apart near Kandos Weir (Dunns Swamp), south-east of Rylstone, NSW, in Wollemi National Park with a total population estimated at less than 100 plants.

New finds

In December 2012, while collecting seed of *Pultenaea* sp. *'Olinda'* with this author, Richard Johnstone (Seedbank Officer with the NSW Seedbank at the Australian Botanic Garden, Mt Annan) collected a voucher specimen of what later proved to be *Baeckea kandos*. More recently, June-September 2013, I collected vouchers from a further 30 new locations. These finds represent a 5 km range extension south from the type location.

Distribution and population size

Based on recent observations, *Baeckea kandos* appears to be restricted to a roughly triangular area of approximately twelve square kilometres in extent immediately south of Dunns Swamp in the lower catchments of Towinhingy Creek, Ganguddy Creek and several unnamed minor tributaries of the Cudgegong River. The type location occupies the most northerly tip of the known distribution. *B. kandos* does not appear to extend as far north or south as does *Pultenaea* sp. *'Olinda'* despite often being found growing with it. All known sites occur in Wollemi National Park.

Total population size is currently estimated at 750–900 plants.

Pockets of dense heath between pagodas. Typical habitat of Baeckea kandos. *Photo: Steve Clarke*

Habitat

At the type location (Kandos Weir), *Baeckea kandos* occurs in heathland or shrubland (Bean 1998) on a rocky hill side a short distance down slope of pagoda rock formations. In this regard the type location is atypical as all the newly discovered sites occur on ledges, in shallow depressions and in deeper clefts within pagoda formations (known colloquially as swarms).

Soils across all sites are sandy, shallow and infertile and are derived from Triassic Narrabeen Sandstone. All known sites occur between approximately 710 m and 820 m elevation and have been found in a wide range of aspects. In the recently discovered sites, *B. kandos* occurs as a co-dominant to dominant component of dense heath. Some sites have a sparse to very sparse *Eucalyptus* and/or *Callitris* canopy. The density of vegetation, (often that of *B. kandos* itself!), makes estimates of population size difficult. Some sites have been estimated to contain 30–50 individuals. The largest site found to date contains an estimated 200–400 plants. Many plants with an estimated height greater than 3 m have been recorded. While flowering is recorded as occurring during December-January, small numbers of flowers have been observed during June-July.

At Kandos Weir, *Baeckea kandos* was recorded as occurring with *Leptospermum parvifolium, L. arachnoides* and *Grevillea evansiana,* (previously known as *G. diffusa* subsp. *evansiana*). In the new sites, in addition to these species, it is found with *Eucalyptus apiculata, Callitris endlicheri, C. rhomboidea, Persoonia linearis, P. myrtilloides, Prostanthera hindii, Leucopogon muticus, L. microphyllus, Ochrosperma oligomerum, Epacris reclinata* and *Dracophyllum secundum.* In addition to *G. evansiana* (listed as Vulnerable under both the *Environment Protection and Biodiversity Conservation Act* and NSW *Threatened Species Conservation Act*), it occurs with several other species of conservation significance such as *Pultenaea* sp. *'Olinda'* (Endangered TSC Act), *Leionema sympetalum* (Vulnerable TSC Act), and *Leionema lamprophyllum* subsp. *orbiculare* (a Rare or Threatened Australian Plant with ROTAP rating of 2R-, meaning that it is a Rare species, represented by a large population in a restricted area or a small population spread over a large area, has a geographic range of less than 100 km and that its reserved population size is not accurately known).

Fire response

Baeckea kandos sheds its seeds annually. The longevity of shed seed and what, if any, dormancy mechanisms exist is unknown. While sporadic germination through time is possible, the presence of dense cohorts of juveniles found in two sites burnt approximately five to six years ago suggests recruitment is largely restricted to mass germination in the immediate post fire period. This would also explain the dense thickets of adult plants mentioned earlier. As no seedlings or juveniles have been seen in unburnt sites, it is possible seed germination is directly cued by fire (heat, smoke etc.) and/or germination and subsequent seedling survival is favoured by the increase in light and nutrients available in the post fire environment. No evidence of post fire resprouting was seen in either of these burnt sites. Several plants contained a small number of fruits suggesting a primary juvenile period (time from seedling emergence to first flowering) of around five to six years, but this is likely to vary depending on average environmental conditions in the first few years post fire.

Conclusion

While the distribution of *Baeckea kandos* is likely to prove highly restricted, these latest finds provide a welcome increase in the critically low numbers previously known and provide some security against inappropriate disturbances such as successive short fire intervals, track and weir maintenance and high recreational use of the Dunns Swamp area affecting what was an extremely small known population and distribution.

Acknowledgments

Sandra King and Paul McKendry provided valuable assistance in the field.

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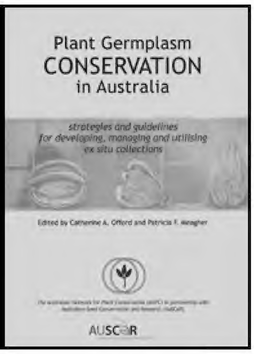
Plant Germplasm Conservation in Australia

Strategies and guidelines for developing, managing and utilising *ex situ* collections

Fully revised edition 2009 | Edited by C.A. Offord and P.F. Meagher

Full of practical case studies on germplasm conservation including seed collection, banking, germination and dormancy.

For more information and to order, go to http://www.anpc.asn.au/publications/germplasm.html


Plant Germplasm
CONSERVATION
in Australia
strategies and guidelines for developing, managing and utilising ex situ collections
Edited by Catherine A. Offord and Patricia F. Meagher
AUSCOR

ANPC Member profile

Graeme Errington

Workplace: Australian Botanic Gardens, Mt Annan, Sydney NSW
Role: Technical Officer
Email: graeme.errington@rbgsyd.nsw.gov.au

What projects are you working on at the moment?

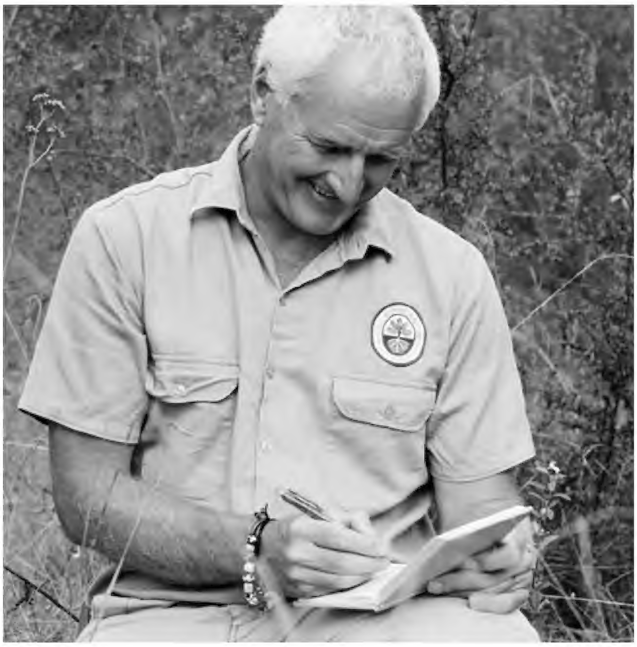
In 2009 I started working on the NSW Seedbank's partnership with the Millennium Seedbank Project which aims to collect and store seeds from dryland communities across the globe. I have travelled all over the state collecting seed, but for the last 18 months I've been working specifically in rainforest communities including subtropical, temperate, littoral and dry rainforests.

To store seeds in the seed bank, we first need to dry them down and then freeze them to maximise their viability and storage longevity. However, we have only limited knowledge of the storage behaviour of seed from rainforest species. We estimate that we can only seed bank 50% of rainforest species. My role is to go out and collect the seeds on 4 or 5 one week trips per year, anywhere between Sydney and the Queensland border, but mainly on the far north coast of NSW where the diversity of species is highest. Along with the seeds, I also:

- collect a specimen for the herbarium to accurately identify the species;
- record the location, GPS reference, number of individuals and associated species;
- take a photo of a specimen in the field.

When I bring the seeds back, I germinate fresh samples, dry some down, and then germinate the dried seeds. Comparing the germination helps us determine whether there has been a dramatic loss in the viability of the seeds after treatment and if seed storage is a suitable conservation strategy. When I find a species that is not suitable for seed banking, I refer it to a couple of my colleagues who investigate alternative germplasm storage such as tissue culture or cryostorage in liquid nitrogen. The recent opening of the new Australian Plantbank has dramatically increased our abilities to undertake this research.

We are also trying to develop a list of characteristics which can help us to identify species suited to seedbanking. In this way we wouldn't have to test every single species, however a lot more information is required before we can do this. Generally speaking, the drier the fruit, the more desiccation tolerant the species will be, but this is not always the case. Seed size also makes a difference - the larger the seed the less likely it is to be able to be dried, and the thickness of the seed coat also plays a part. If one species in a genus responds well to seed banking, chances are that other related species will too.



We have just completed a trip, including a visit to a dry rainforest community near Warialda on the north west slopes. It will be interesting to compare desiccation tolerance strategies from species found in this location to those of related species from the wetter rainforest communities.

How long have you been involved in the ANPC?

I have been reading APC at work for many years now and finally joined ANPC 2 years ago. Then I gave a presentation at the ANPC Conference in 2012 titled '*Seeds behaving badly: Conservation of rainforest species*' which was published in APC 21(3) and assisted at the first ANPC Seed Collection Workshops in 2012.

How did you end up working in plant conservation?

I guess it was a gradual progression. I was always interested in conservation issues from an early age and studied horticulture after I left school. Then in the early 1990s I was employed as horticulturist at the Mount Annan Botanical Garden where I was exposed to rare and threatened plant species which inspired my interest in plant conservation. This was just prior to the introduction of the NSW *Threatened Species Conservation Act 1995* when there was a growing level of support for rare and threatened plants from both the government and the community.

Then just after that, I got the chance to 'act-up' in the Seedbank when someone went overseas for a few months. Prior to that I didn't know anything about seeds! But while I was there I thought 'hey, this is great' and then when that person soon resigned, I got the job! I saw the opportunity to do some really interesting and important work, which in the field of plant conservation can sometimes be not that easy to achieve due to budget constraints. Although it isn't the ideal situation, seed banking is an important part of the conservation strategy for threatened plants. I worked as the Seedbank Officer for a couple of years, left for 10 years, then came back in 2009.

I've just finished my honours degree, where I investigated desiccation tolerance, response to freezing and longevity of seeds from a small group of rainforest species seeds affected by myrtle rust, including a couple of *Backhousia* and *Syzygium* species.

What are some of the logistical hurdles you have had to overcome?

Collecting seeds from rainforest species does have its challenges. The biggest of these is just getting the numbers of seed required to enable a proper assessment and achieve the genetic diversity required. Generally speaking, when collecting from dry species, it's relatively easy to collect high volumes of seed from a number of individuals (ideally 30 or 40). However, for many rainforest species, you might have one tree in a certain area, but the next tree of the same species might be half a kilometre away! So if you can collect from 10 trees that's good but sometimes there'll only be one individual available. Also the seeds are sometimes at the top of a 30 metre tree, so we might need to wait until the seeds fall down!

Much of the seed collecting I did in the dry communities was mostly 'on reserve' in national parks or state forest. However with rainforest communities in NSW, there are a lot of small remnants on private land, so I have to spend many days on the phone negotiating with landholders to get access to their properties and arranging for convenient times to visit.

However, timing is usually in my favour. I can generally go to an area where rainforest communities occur at any time of the year and there's something available to collect – this is uncommon in dryland communities where you often need to be there at a particular time, within a couple of weeks or even days. There seems to be a wider window of opportunity with rainforest species as many fruit for a longer period. To help with timing collection, I often engage a local botanist who will keep an eye out and let me know when a particular species is fruiting.

Our seed collecting trips are a part of the Seedbank project that people rarely get to see, so we've recently started uploading photos and updates in the field on Facebook which has had a great response so far. So if you'd like to keep up with where we are and what species we are collecting, follow us on the Australian Botanic Garden, Mount Annan Facebook page!

Recent workshop reports

AMR 2013: Australian Mining Rehabilitation workshop, Adelaide

Dr Amelia Martyn

Australian PlantBank, Royal Botanic Gardens and Domain Trust

I travelled to Adelaide in August on behalf of ANPC to present at the 2 day conference coordinated by SMI Knowledge Transfer, a business unit of JK Tech. This second mining rehabilitation workshop brought together sixty environmental officers, regulators, consultants and researchers from around Australia, along with attendees from Papua New Guinea and New Zealand. A summary of workshop presentations follows.

Day 1: strategy and design

Dr Carl Grant of Anglo American Metallurgical Coal gave a keynote address, outlining the development and implementation of a mine rehabilitation strategy. The objective of rehabilitation is to return land to a condition that is "*safe, stable, non-polluting and sustainable that considers stakeholder expectations*". Carl reminded the audience that rehabilitation was one part of an integrated mine plan, which changes over time. He emphasised the need to accurately calculate the financial benefits of rehabilitation, as well as the less tangible benefits for the company, and to be confident, flexible and persistent in engaging with senior mine management.

Ms Danelia Robinson followed with an overview of the Penrith Lakes Development, whose Corporation

Recent workshop reports (cont.)

has partnered with the NSW Government to rehabilitate the largest sand and gravel quarry in Australia. With the quarry due for closure in two years, the Natural Heritage and Biodiversity Master Plan provides for the development of an area of four lakes with surrounding vegetation providing opportunities for recreation and conservation. The development will reinstate the links between the adjacent World Heritage Area and peri-urban development.

AMR2013
Planning for Rehabilitation Success
Adelaide, South Australia
7 - 9 August 2013
ILUKA
SMI

Conference organisers Lauren Kerr and Bruce Barrie from SMI Knowledge Transfer. Photo A. Martyn

The remainder of presentations on Day 1 were technical summaries concerned with designing and mapping waste land forms (waste rock stockpiles, covers and tailings dams) and quantifying and assessing their contents. Increasingly, mine operators are realising the need for well-planned, engineered solutions to deal effectively with mine wastes, requiring expertise in soil science, geology, geochemistry, hydrology and engineering. Dr Rob Loch outlined future trends in waste landforms, such as the need to consider the impact of extreme climatic events, better understand topsoil handling and stockpiling in different conditions, and the development of rapid analysis methods such as on-site laboratories for more timely decision-making.

Day 2: soil and vegetation

Day 2 moved into the soil and vegetation components of rehabilitation, beginning with a keynote address from Dr Longbin Huang of the University of Queensland. Huang reminded the audience of the essential biological and geochemical components of man-made soils, and the time taken for their evolution. The second speaker Dr Thomas Baumgartl again emphasised the decades required for soils to reach equilibrium following mining. Baumgartl discussed rehabilitation of prime agricultural land following mining, which may become increasingly important in the Australian landscape, and provided examples from the US and Germany.

I provided an overview of advances in seed research in Australia, with colleagues around Australia providing input and images during preparation of the presentation. Three themes were covered: 1) increasing seed quantity and quality through seed production areas, 2) sourcing seed from healthy populations to ensure resilience and adaptation to changing conditions over time and 3) improving seed storage by understanding species variation in seed longevity (a project of the Australian Seed Bank Partnership, previously reported in APC 17(4):9–10). Dave Merritt provided useful graphics showing the process of seed use from collection, banking, characterisation and enablement to illustrate the importance of understanding each step to achieve a successful rehabilitation outcome.

Examples of rehabilitation in a variety of settings followed: Mr Pikus Evino impressed the audience with his development of specialised rope access techniques to facilitate rehabilitation of steep slopes around mines in Papua New Guinea. Dr Travis How talked about regeneration and management of bushland at the Kanmantoo Copper Mine in the Adelaide Hills, where the site provides one of the only opportunities to consolidate and improve fragmented woodland areas close to the town. They are using seed production areas to support rehabilitation of mined areas adjacent to woodland, as well as areas heavily compacted by vehicle movement. Dr Robyn Simcock outlined a novel approach to mine rehabilitation in New Zealand, using direct transfer of sods to bring plants, insects and microbes into disturbed areas.

Workshop conclusions and future directions

The mining industry is keen to engage further with people skilled in vegetation management, from seed production, use and propagation to management of disturbed sites and complex soil environments. There was some frustration that much critical information was known but not well-implemented throughout industry. The challenge may be in providing practical examples linking anthropogenic soils, propagules from stockpiles or seed collections, and establishment of plants under tough conditions, to exceed the current threshold that sees only 10% of broadcast seed established (Merritt and Dixon, 2011). The next Australian Mine Rehabilitation conference planned for 2015 in Adelaide will be an ideal forum to convene and discuss advances in the wide range of activities that contribute to successful mine rehabilitation.

Thanks

Thanks to the ANPC, particularly Bob Makinson, and the conference organising committee for the opportunity to present in this forum, and the eye-opening insight into rehabilitation following mining. Thanks to Paul Gibson-Roy, Tim Zwiersen, Linda Broadhurst and researchers in the Australian Seed Bank Partnership for helping develop the themes in my presentation.

Recent workshop reports (cont.)

ANPC workshop report

Tricia Hogbin
Australian Network for Plant Conservation, projects@anpc.asn.au

The ANPC delivered a workshop on 'Plant Identification for Flora of the Wimmera' in Horsham, Victoria in October 2013. As is typical for ANPC workshops, a key strength was the diversity of presenters and participants involved. We wish to acknowledge and thank the support of the Wimmera Catchment Management Authority, Landcare Wimmera, and the generous workshop presenters including: Neville Walsh and Daniel Murphy of the Royal Botanic Gardens Melbourne, Isobel Crawford from Australian Botanical Surveys, Noushka Reiter from the Wimmera Catchment Management Authority, Geoff Carr from Ecology Australia, and locals Maree and Graeme Goods.

Learning was through a combination of theory presentations, practicals and field-based activities. Participants had an in-depth look at identifying a range of common families including Orchidaceae, Fabaceae, Poaceae, Liliaceae, and Asteraceae. There was plenty of hands-on practice identifying species from these families using a botanical key.

Participants learnt how to use a hand lens and dissecting microscope, recognise parts of a flower, collect a herbarium specimen, and recognise families by looking for 'giveaway characters'. They were also provided with an overview of relevant resources.

Neville Walsh and Isobel Crawford instructing participants on how to use a dissecting microscope. Photo: Tricia Hogbin

Workshop participants learning how to properly use a hand lens. Photo: Tricia Hogbin

A full workshop report, including Neville Walsh's presentation on the diversity and ecology of the flora of the Wimmera, can be found at http://www.anpc.asn.au/courses.html.

Future plant identification workshops

The ANPC has now delivered three plant identification workshops in the past year. Given the positive feedback received and apparent demand for plant identification training, the ANPC is keen to deliver this workshop in other regions of Australia. Please contact the ANPC National Office if you would like to discuss opportunities for delivery of plant identification training in your region.

Upcoming workshops

The ANPC will be delivering two workshops in the Hunter Valley NSW in April 2014. Further information is provided on the back cover of this issue. A range of other workshops are currently in development. To be notified of upcoming workshops subscribe to our monthly email newsletter ANPC News at http://www.anpc.asn.au/.

Upcoming conferences and workshops

The ANPC will be delivering two workshops in the Hunter Valley NSW in April 2014. Further information is provided on the back cover of this issue.

Green Cities 2014: Beyond the baseline

18–19 March 2014
Melbourne Vic

Green Cities is a conference for sustainability in the built environment. Green Cities 2014 will be a forum for discussion, demonstration and debate on how to go beyond market challenges, beyond greenwash, beyond boundaries.

The Green Cities 2014 program will be carefully distilled into two distinct yet complementary days. Day 1: BLUEPRINT sees world-leading sustainable thinkers contribute their experiences, thoughts and actions to the discourse on our sustainable future. Day 2: IMPRINT sees our industry come together to share tools, tactics and techniques to construct a greener built environment. For more information visit http://www.greencities.org.au/

5th National Natural Resource Management Knowledge Conference

17–19 March 2014
Launceston, TAS

National NRM Knowledge Conferences bring together regional NRM organisations from around Australia, along with NRM practitioners from Australian and State/ Territory agencies and non-government organisations, to share knowledge and experiences in Natural Resource Management.

This year our theme is *Regional NRM – Communities in Action: viable communities, productive and healthy landscapes.* It reflects our core value of working with communities to address the NRM challenge – it's the communities that do the work whether it be changing farm practices or establishing wildlife corridors and in doing so they are supporting the long-term sustainability of their farming and biodiversity assets.

For more information visit http://www.conference.nrmregionsaustralia.com.au/

Society for Conservation Biology Oceania Fiji 2014 conference

9–11 July 2014
Suva, Fiji

The Fiji Conference 2014 provides opportunities for researchers to present their work in focused symposia related to the main conference themes:

- Vulnerable Ecosystems, Communities and Species
- Adaptive & Community Based Management of Socio-Ecological Systems
- Conservation in a Changing Oceania.

Workshops will be held prior to the Fiji conference on July 7–8, 2014. For more information visit http://www.scbo2014.usp.ac.fj/

Australasian Network for Ecology and Transport Inaugural conference

20–24 July 2014
Coffs Harbour, New South Wales

The Australasian Network for Ecology and Transport (ANET) is a professional network for all people involved in the planning, design, construction, maintenance and research of linear infrastructure and the environment. Roads, railways and utility easements are conspicuous and pervasive components of almost all landscapes around the world. The impacts of linear infrastructure and the vehicles they carry are are considerable and are responsible for the mortality of hundreds of thousands of animals each year, the decline of populations and disruption to ecosystem function. Road ecology is a relatively new discipline that aims to understand impacts and offer strategies and approaches to avoid, minimise, mitigate and offset these impacts. With support from the NSW Roads and Maritime Services, the conference will provide an opportunity to learn more and share your experiences with others.

Further program and conference registration information will be posted on the ANET website http://www.ecoltrans.net

Island Biology 2014
An International Conference on Island Evolution, Ecology, and Conservation

7–11 July 2014
Hawaii, USA

This international conference consisting of plenary lectures, symposia, contributed talks, and posters will examine a broad range of taxa, regions, and biological disciplines. This will be the first of a regular series of meetings that will be held every four years, on islands around the world, at which island biologists can come together, share insights, and develop collaborations that will accelerate the pace and effectiveness of island research and conservation. Conference themes will include:

- Island biogeography: confronting theory with reality;
- Island evolution: time for a data-driven synthesis across taxa and islands;
- Island ecology: how do islands differ from continents, and from each other (and what do they have in common)?

Upcoming conferences and workshops (cont.)

- Island conservation: island biodiversity faces extraordinary threats, so how can we respond?
- Emerging topics: paleoecology, climate change, ecosystem services, novel ecosystems.

For more information visit https://sites.google.com/a/hawaii.edu/islandbiology2014/

Conference on ecological and ecosystem restoration

28 July - 1 August 2014
New Orleans, Louisiana, USA

Through a multidisciplinary, interactive forum, the Conference on ecological and ecosystem will:

- address the latest innovations, methods, and tools for combating ecosystem and ecological degradation;
- enable ecological and ecosystem restoration professionals to exchange ideas and lessons learned from past and ongoing restoration efforts from colleagues and other restoration practitioners at both national and international levels;
- explore the roles of policy, planning and science in establishing goals and achieving successful and sustainable ecological and ecosystem restoration, and assessing and incorporating ecosystem services into the public and private decision-making process;
- share experiences and explore the roles of state-of-the art science, methods, tools, processes, engineering, planning and policy as applied to ecological and ecosystem restoration efforts.

For more information visit http://www.conference.ifas.ufl.edu/CEER2014/

2014 Government Sustainability Conference

12–13 August 2014
Sydney, NSW

The 2014 Government Sustainability Conference will again provide delegates from local, state and federal government and the wider public sector with comprehensive analysis and advice on how to address crucial environment issues and embed sustainability within their organisations. By focusing on the environmental issues that need to be addressed by governments and authorities, this conference has become the peak annual environment conference for Australia's public sector. This national conference will provide attendees with the means to network and discuss environmental best practice with officials from the nation's public sector sustainability leaders. The conference will also provide attendees with high-quality information and case studies that will assist them to address crucial environmental issues facing all levels of government.

For more information visit http://commstrat.cvent.com/events/government-sustainability-conference/event-summary–1bfec4980ea442d9a4f32e337c8ea160.aspx

19th Australasian Weeds Conference

1–4 September 2014
Hobart, Tasmania

The Tasmanian Weeds Society, in conjunction with the Council of Australasian Weeds Societies Inc. will host the 19th Australasian Weeds Conference. This conference will focus on the conference theme of 'Science, Community and Food Security: the Weed Challenge'. The theme reflects the changing state and developing challenges management and will highlight with new developments internationally and nationally.

For more information visit http://australasianweeds2014.com.au/

Ecological Society of Australia 2014 Annual Conference

28 September - 3 October 2014
Alice Springs, Northern Territory

The conference will feature symposia on regionally relevant issues such as arid ecology, the ecology of northern development, and Indigenous ecological knowledge. However, it will cover the full range of biomes, from deserts to oceans, and embrace all aspects of ecological theory and practice.

For more information visit http://www.esa2014.org.au/

Botanic Gardens of Australia and New Zealand Biennial Conference

2–4 October 2014
Cairns, QLD

The Botanic Gardens Australia and New Zealand promotes the interests and activities of Australian and New Zealand botanic gardens and botanic gardens generally and enhances the state of botanic gardens for the benefit of the community. This year's conference theme is "cultivating connections".

For more information visit http://www.bganz.org.au/index.php/5–7-june–2014-cairns-bganzq-biennial-conference

Upcoming conferences and workshops (cont.)

EIANZ Conference 2014

30–31 October 2014
Hobart, Tasmania

The Environment Institute of Australia and New Zealand are holding their conference in Hobart in October this year.

For more information visit http://www.eianz.org/conference

10th Australasian Plant Conservation Conference Sustaining Biodiversity – Adapting to a Changing World

11–14 November 2014
Hobart, Tasmania

The ANPC's national conferences provide a major forum for conservation practitioners, community members and the scientific community to interact at a practical level. The ANPC conference will provide:

- presentations on the latest findings relevant to plant conservation and native vegetation rehabilitation;
- practical workshops on ecologically sound techniques;
- field visits demonstrating rehabilitation in action;
- social activities to enhance networking.

More information will be available at http://www.anbg.gov.au/anpc/conferences.html

2014 IUCN World Parks Congress

12–19 November 2014
Sydney, NSW

The IUCN World Parks Congress is a landmark global forum on protected areas held every ten years. As the world's most influential gathering of people involved in protected area management, it sets the global agenda for the following decade. As challenges in sustainable development and sustainable use of the earth's natural resources accelerate, the 2014 IUCN World Parks Congress will play a key role in ensuring that protected areas can contribute towards addressing them. The ultimate aim of the Congress is to position parks and protected areas firmly within broader goals of economic and community wellbeing. The theme of the Congress has therefore been selected as Parks, People Planet: Inspiring Solutions.

For more information visit http://www.iucn.org/about/work/programmes/gpap_home/gpap_events/gpap_wpc

Botanic Gardens of Australia and New Zealand, NSW Regional Conference

23 Nov 2014
Dubbo, NSW

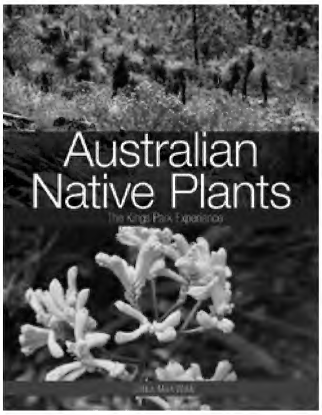
The Botanic Gardens Australia and New Zealand promotes the interests and activities of Australian and New Zealand botanic gardens and botanic gardens generally and enhances the state of botanic gardens for the benefit of the community. This year's conference theme is "cultivating connections".

For more information visit http://www.bganz.org.au/

Book review

Australian Native Plants: The Kings Park Experience

Edited by Mark Webb
CSIRO publishing, June 2013
144 pages with colour photographs and illustrations
Paperback, ISBN:9780643103214
Price: AU $39.95
Available from: http://www.publish.csiro.au



There have been many books published over the years on how to grow Australian plants, so what makes "*Australian Native Plants: The Kings Park Experience*" any different from these others? This book is a contemporary and very much up-to-date approach to the subject and is based on nearly 50 years of experience. It describes the horticultural requirements, with easy-to-follow tips, for successfully growing mostly WA native plants, along with chapters on arboriculture, plant propagation, grafting, tissue culture, seed collection and storage, the role of smoke in improving germination, as well as how to recognise and treat a large range of

Book review (cont.)

problems, pests, diseases. The final chapter rounds it all out exceedingly well by describing the results of an ongoing programme of selection and breeding and, along with the use of somatic fusion to create intergeneric hybrids, is aimed at producing more horticulturally desirable and reliable plants for our gardens.

The enormous wealth of Kings Park expertise is well illustrated in the chapter on propagation, where a huge amount of data about propagation from seed and cuttings, as well as grafting, is included. This data is shown in table-form making it easy to refer to, and includes comparisons between various potting media, successful scion and rootstock combinations for grafting, characteristics of selected rootstocks and, for over 270 WA species, the average number of days it takes for cuttings to strike. This chapter alone, for both the amateur and professional propagator alike, makes the book worth owning.

Whilst the chapter on arboriculture is aimed more at park managers, I found the section on the new-generation of three-dimensional-air-root-pruning pots (3DARP) particularly interesting. The previous design of air-pruning pots with root-training ribs produced quite an improvement in root structure. However it appears these 3DARP pots will produce even better root architecture and hence further reduce the incidence of root-girdling.

The text is easily understood, the high-quality colour photographs are legion, and in places quite beautiful; they appropriately illustrate and complement much of the text, and add to the enjoyment of the reading. However, there are a couple of slips with labelling; on p.11, the left-hand image is incorrectly labelled as *Banksia blechnifolia* (it should be *B. nivea*) and on p.68, the image should be *Melaleuca cardiophylla* (and not *M. huegelii*)

There are two minor disappointments: very little emphasis is given to the need for collecting permits, (although the ethical and environmentally sustainable collection of material from the wild is pleasingly mentioned several times), plus the index lacks detail. A more comprehensive index with better cross-referencing would make it easier to use. In addition when looking up a subject, there are several instances where one needs to 'see' another reference rather than being able to go directly to the relevant page. It would be much simpler, and more user-friendly' to just repeat the page numbers!

This marvellous book is aimed at a wide audience, complements an increasingly mainstream desire to grow Australian, and especially 'local' Australian, plants, and illustrates how year-round colour can be achieved with a diversity of foliage type and plant form.

I have no hesitation in recommending it to anyone who has the slightest interest in growing Australian plants.

Dave Bright, Regen4 Environmental Service, Perth, Western Australia

Information resources and useful websites

Australian Association for Bush Regenerators

http://www.aabr.org.au/

The Australian Association for Bush Regenerators (AABR) recently launched a new website as part of changes to their membership system.

AABR promotes the study and practice of ecological restoration, and fosters and encourages effective management of natural areas by qualified people, based on sound ecological principles.

For the last 25 years, AABR membership has been awarded as a form of accreditation as a bush regeneration practitioner – with other interested people being "subscribers". Membership is now open to everyone and accreditation is awarded through a separate process.

Australasian Network for Ecology and Transportation

http://ecoltrans.net/

The Australasian Network for Ecology and Transportation (ANET) is a new professional network dedicated to the research, design and implementation of environmentally-sensitive linear infrastructure (rail, roads and utility easements) across Australasia. ANET acts as a hub, providing links between government, industry, scientists and community groups to ensure all have access to current evidence and best practice.

Information resources and useful websites (cont.)

Science Media SAVVY

http://sciencemediasavvy.org/

This website by the Australian Science Media Centre aims to help scientists work more effectively with the news media. It provides an understanding of the news media cycle, what journalists want from scientists and tips for working with TV, radio and print.

Special issue of ESA Frontiers assesses impacts of climate change on ecosystems

http://www.esajournals.org/toc/fron/11/9

The November 2013 issue of the Ecological Society of America's journal *Frontiers in Ecology and the Environment* is devoted to an assessment of climate change effects on ecosystems, and the consequences for people. The Special Issue tackles five major topics of concern, including biodiversity, ecosystem functionality, ecosystem services, combined effects of climate and other pressures, and preparation for change. The collection is aimed at both ecologists and practitioners and is available online free via open access.

Ticks and tick-borne diseases – protecting yourself

http://www.aabr.org.au/aabrs-tick-guide-now-available/

This free guide provides an overview of how to protect yourself from ticks & tick-borne diseases. Produced by the Australian Association for Bush regenerators (AABR), the guide was prompted by a number of bush regenerators and ABBR members testing positive to Lyme disease and its co-infections in recent years. The guide includes information on removing ticks, how to protect yourself from tick-borne diseases, and how to prevent tick bites.

Urban Environment News

http://www.urbanenvironmentnews.com/

Ahead of its 10th anniversary next year, Urban Environment News has a new website where you will find the latest environment, sustainability and natural resource management news for cities and towns across Australia and internationally.

Research round up

Compiled by Kirsten Cowley

Centre for Plant Biodiversity Research, Canberra. Email: Kirsten.Cowley @csiro.au

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Research round up (cont.)

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Contributions to Research Roundup are welcome, and should be sent to Kirsten Cowley at the above email address using an email subject heading “APC Research Roundup” or similar. Their inclusion will be subject to available space.

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AABR

Australian Association of Bush Regenerators

Working with natural processes

The Australian Association of Bush Regenerators (AABR) was incorporated in NSW in 1986. It now has several hundred members all over Australia.

Our activities reflect our commitment to promote the study and practice of ecological restoration, and encourage effective management of natural areas.

AABR membership is now open to all interested people and organisations.

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Details of ways to become a member (or to gain practitioner accreditation) are available on our website.

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